Original Article

Single-port insufflation endoscopic nipple-sparing mastectomy in early breast cancer: a retrospective cohort study

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Background: Breast cancer is the most common malignancy in female patients. In recent years, more and more studies have focused on how to improve the appearance and the quality of life for patients. This study aimed to compare the oncologic safety, aesthetic results, and upper extremity function between single-port insufflation endoscopic nipple-sparing mastectomy (SIE-NSM) and conventional open mastectomy (C-OM) in early-stage breast cancer treatment.

Methods: In our retrospective cohort, 285 patients with stage I and II breast cancer were categorized into the SIE-NSM group (n=71) and the C-OM group (n=214). We assessed local recurrence, distant metastasis, and upper extremity function across the two groups. The BREAST-Q scale was employed to analyze differences in aesthetic results, psychosocial well-being, and sexual health. The risk of local recurrence was evaluated using multivariable binary logistic regression, while a multivariable linear regression model gauged upper extremity function and aesthetic outcomes.

Results: Local recurrence rates between the two groups were statistically similar (1/71, 1.4% for SIE-NSM *vs.* 2/214, 0.9% for C-OM, P=0.735), as confirmed by the multivariable binary logistic regression analysis. Neither group exhibited distant metastases. The SIE-NSM group demonstrated higher scores in satisfaction with breasts, chest wellness, psychosocial health, and sexual well-being (P<0.001). The SIE-NSM group also exhibited superior outcomes regarding chest wall/breast pain, shoulder mobility, and daily arm usage (P<0.001). No subcutaneous effusion was reported in the SIE-NSM group, whereas the C-OM group had a 10.7% incidence rate (P=0.004).

Conclusions: SIE-NSM offers comparable oncologic safety to C-OM but provides enhanced satisfaction regarding breast appearance, physical comfort, psychosocial health, sexual health, and improved upper extremity functionality. Consequently, this innovative approach is a suitable surgical alternative for treating early-stage breast cancer.

Keywords: Breast cancer; single-port; endoscopic; endoscopy-assisted; nipple-sparing mastectomy (NSM)

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Introduction

Breast cancer is the most common malignancy jeopardizing women's health worldwide, with its annual incidence rates surging notably in recent years (1,2). Given the breast's significance as a secondary sexual organ, breast cancer patients express heightened expectations for post-surgical aesthetics and post-treatment psychosocial and sexual well-being.

Conventional open mastectomy (C-OM) can result in a major change in breast appearance with massive loss of skin on the breast surface and limiting the traction and movement of the affected upper extremity. These factors seriously influence a patient's quality of life (3,4). The development of the nipple-sparing mastectomy (NSM) in which the nipple-areola complex (NAC) can improve the postoperative aesthetic outcome to a certain degree (5,6), and thus the quality of life and satisfaction of the patients can be improved too (7-9). However, after open NSM, a conspicuous surgical scar will still be left on the chest wall. An areolar incision can be used to reduce the size of the scar, but it is accompanied by a high NAC necrosis rate (10). Therefore, open NSM cannot fully meet the aesthetic demand of patients.

Endoscopic surgery has gained traction in clinical settings due to its merits of minimalistic incisions and expedited recovery (11). There is a pressing need to further adapt endoscopic techniques in breast cancer surgeries to enhance aesthetic results, psychosocial health, and upper extremity function. Our facility employs the SIE-NSM approach, creating a discreet single-port incision within the axillary fossa instead of on the chest wall. This technique circumvents the potential disruption to the NAC blood supply that can occur with an areolar incision. In this investigation, we juxtaposed the outcomes of SIE-NSM with those of C-OM, examining variances in oncologic safety, aesthetic results, psychosocial health, sexual well-being, and upper extremity function. We present this article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-23-148/rc).

Highlight box

Key findings

- Single-port insufflation endoscopic nipple-sparing mastectomy (SIE-NSM) is comparable in performance to conventional open mastectomy (C-OM) in oncologic safety, with higher satisfaction with breasts and physical, psychosocial, and sexual well-being, as well as better upper extremity function.

What is known and what is new?

- C-OM is disadvantageous in terms of aesthetics.
- SIE-NSM can increase satisfaction with breasts and physical, psychosocial, and sexual, as well as upper extremity function.

What is the implication, and what should change now?

- SIE-NSM can achieve better aesthetic outcomes and sexual and psychosocial well-being, as well as upper extremity function. It may be considered in appropriate patients, such as those with small breasts and those who do not wish to undergo reconstruction.

Methods

Ethical statement

This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University, China (No. 2019-P2-033-02). The study was conducted per the Declaration of Helsinki (revised in 2013). Informed consent was waived due to the retrospective nature of this study.

Data source and patient selection

This was a retrospective cohort study. The medical records of 285 patients with stage I and II breast cancer were consecutively enrolled. They underwent surgery at the Beijing Friendship Hospital from January 2014 to October 2018. In total, 71 patients received SIE-NSM, and 214 patients received C-OM (*Table 1*). Written informed consent was obtained from all patients before surgery.

The inclusion criteria for patients were as follows: (I) diagnosis of stage I or II invasive ductal carcinoma; (II) absence of involvement of the nipple and skin as determined by physical examination and magnetic resonance imaging (MRI), and the tumor was confined to the mammary gland as confirmed by MRI; (III) the diameter of the tumor was no more than 3 cm, the distance between the lesion and nipple was >3 cm, and clinically negative infused axillary nodes were present; (IV) breast-conserving therapy cannot be performed because of the presence of diffused suspicious neoplastic foci or microcalcifications and the small size of the breast; (V) unwilling to undergo breast reconstruction surgery for personal reasons; (VI) age between 18 and 70 years old; and (VII) Eastern Cooperative Oncology Group scoring from 0–2.

The exclusion criteria were as follows: (I) suffering from

Table 1 Patient characteristics (n=285)

Variables	SIE-NSM group (n=71)	C-OM group (n=214)	P value
Age (years)	52.6±10.6	56.7±8.7	0.001
BMI (kg/m²)	22.9±3.0	23.3±2.7	0.381
Tumor size (cm)	1.7±0.6	2.0±0.6	0.002
Follow-up time (months)	81.1±21.3	80.1±16.7	0.715
TNM stage			0.661
I	50 (71.0)	143 (66.8)	
II	21 (29.0)	71 (33.2)	
ER			0.873
+	55 (77.5)	162 (75.7)	
−	16 (22.5)	52 (24.3)	
PgR			0.775
+	47 (66.2)	136 (63.6)	
−	24 (33.8)	78 (36.4)	
HER2†			0.773
+	25 (35.2)	71 (33.2)	
−	46 (64.8)	143 (66.8)	
Ki67‡			0.371
+ (20%)	27 (38.0)	69 (32.2)	
− (<20%)	44 (62.0)	145 (67.8)	
Chemotherapy	30 (42.3)	96 (44.9)	0.702
Endocrine therapy	58 (81.7)	170 (79.4)	0.681
Targeted therapy	25 (35.2)	71 (33.2)	0.753

Data were presented as mean ± SD for continuous data or n (%) for categorical data. †, *HER2* status was estimated by immunohistochemistry or *in situ* hybridization. Tumors were *HER2* positive if the average *HER2* gene/chromosome 17 ratio was 2, or the average *HER2* gene copy number was 6; ‡, Ki67 was determinedusing immunohistochemistry. Tumors were Ki67 positive if Ki67 ≥20% and negative if Ki67 <20%. SIE-NSM, single-port insufflation endoscopic nipple-sparing mastectomy; C-OM, conventional open mastectomy; BMI, body mass index; TNM, tumor-node-metastasis; ER, estrogen receptor; PgR, progesterone receptor; *HER2*, human epidermal growth factor receptor 2; SD, standard deviation.

severe internal disease including cardiovascular disease, myocardial infarction, and cerebrovascular disease; (II) pregnant or lactating; (III) other tumor histories within the past 5 years; (IV) continued systemic steroid therapy or organ transplantation requiring immunosuppressive therapy; and (V) severe breast ptosis.

To avoid the impact of breast reconstruction on the local recurrence and BREAST-Q scores, the patients requiring breast reconstruction combined with SIE-NSM were not enrolled in this study. Our center is working on another study to determine the effects of silicone breast reconstruction and SIE-NSM.

Clinicopathologic parameters

The primary endpoint was local recurrence after the operation. The secondary endpoints were distant metastasis, breast satisfaction, chest well-being, psychosocial well-being, sexual well-being, incidence of subcutaneous effusion, and upper extremity function (including upper arm pain, chest wall/breast pain, shoulder range, and use of arm in daily life).

Surgical procedures

SIE-NSM

Endoscopic instruments and optics were sourced from a

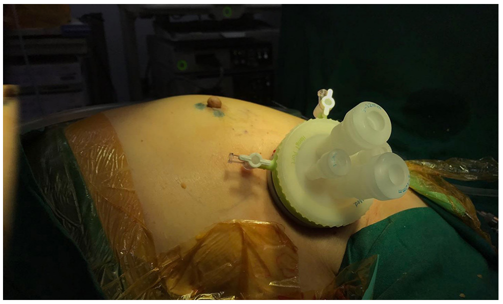

Figure 1 Operation set-up. The working space was created by the insufflation method with the single-port insufflation kit.

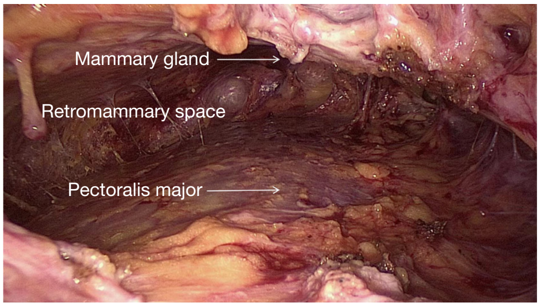

Figure 2 Retromammary space was revealed after liposuction.

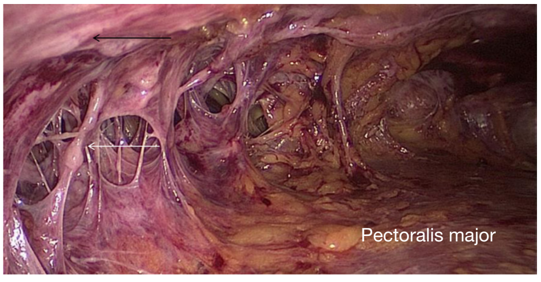

Figure 3 Membrane anatomy of the breast. Different surrounding ligaments connect the mammary gland. Horizontal ligaments (white arrow) anchor the mammary gland (black arrow) directly to the fourth, fifth, and sixth ribs creating the inframammary fold.

reusable laparoscopy kit (Olympus Optical Co., Tokyo, Japan). The patient was positioned supine, with the affected arm abducted to 90° and the corresponding side of the body elevated.

To determine the blood supply pattern of the NAC, we administered 4 mL of a 2.5 mg/mL indocyanine green solution intravenously, followed promptly by indocyanine green angiography. We introduced a carbon nanoparticle suspension around the areola for sentinel lymph node mapping. About 15 minutes later, we made a discrete 2.5 cm single-port incision in line with the axillary creases. Sentinel lymph node biopsy was conducted through this incision under direct visualization. Intraoperative frozen pathology dictated the necessity for axillary lymph node dissection. Patients undergoing axillary lymph node dissection were excluded from our study.

To establish a workspace for the endoscopic maneuvers and visualize the breast tissue layers, we preceded mammary gland resection with tumescent solution infiltration and liposuction. The tumescent solution comprised: 1 mg of adrenaline, 20 mL of 2% lidocaine, combined with 250 mL of 0.9% saline and 250 mL of sterilized distilled water. This solution was introduced into the subcutaneous layer and the retromammary space via the single-port incision. A decade of minutes post-injection, liposuction, employing an 800 mbar vacuum, was initiated in both the subcutaneous layer and retromammary space, removing surrounding adipose tissue.

We carved out an optimal operating arena utilizing the insufflation technique. The single-port insufflation kit (HTKD-Hang T Port, China) was positioned into the aforementioned single-port incision. This kit featured dual side pathways. We used carbon dioxide, delivered at a rate of 8 L per minute, to sustain a pressure of 8 mmHg. The exterior of this insufflation kit was equipped with four plastic trocars, facilitating the introduction of various endoscopic tools into the surgical field (see *Figure 1*).

We subsequently executed the SIE-NSM via this single-port insufflation kit. Initially, the retromammary space was delineated, made evident post-liposuction and with the introduction of carbon dioxide (refer to *Figure 2*). A straightforward separation of the mammary gland from the pectoralis major was achieved by cleaving the fibrous connective tissue. After that, we detached the mammary gland from the skin flap by severing Cooper's ligaments, which were its sole attachments post-liposuction. Peripheral ligaments primarily tethered the gland at this juncture, including the clavicular, medial sternal, lateral pectoralis major, and horizontal ligaments (see *Figure 3*) (12). These ligaments were severed using electrocautery, leading to the complete isolation of the gland. To aid pathologists in determining specimen orientation and margin analysis, the lateral margin of the specimen was delineated using hemlock clips. Conclusively, the entire breast tissue was extracted through the base of the single-port insufflation kit, a strategy aimed at averting incision implantation metastasis

Figure 4 The entire mammary gland specimen was removed through the base part of the single-port insufflation kit.

(illustrated in *Figure 4*). Specimens from the nipple's stump and the dissected tumor surfaces were immediately subjected to intraoperative frozen section analysis.

C-OM

The operative position and the sentinel lymph node tracing were the same for C-OM as described above for SIE-NSM. We made a spindle-shaped incision on the surface of the breast, including the NAC, that was approximately 15 cm long. Then, the entire breast tissue was removed and sent to pathology. A sentinel lymph node biopsy was performed. If the frozen section examination showed positive results, axillary lymph node dissection was performed. Patients with axillary lymph node dissection were not included in the study.

Postoperative management

In the C-OM group, two closed suction drainage tubes were placed. In the SIE-NSM group, one drainage tube was placed through the single-port incision because subcutaneous effusion is rare. The drainage tube was removed when the drainage volume was less than 30 mL for 3 consecutive days. The pressure bandaging was used for 2 weeks after removing the drainage tube. According to the National Comprehensive Cancer Network guidelines, all patients could accept corresponding chemotherapy, endocrine therapy, and targeted therapy (13).

Follow-up

All patients were followed up by telephone and questionnaire 12 months after the operation. The aesthetic outcome was evaluated using the BREAST-Q scale (14). The upper extremity function was evaluated with a questionnaire with scores ranging from 1–10 (1 indicated the worst function, and 10 indicated the best function).

Statistical analysis

The sample size was determined based on the primary endpoint of local recurrence within 2 years post-surgery, using a noninferiority margin of 5.0%. The patient assignment ratio between those undergoing SIE-NSM and C-OM was 1:3. Assuming a one-sided significance level of 0.025, 80% statistical power, and a projected 10% dropout rate, we determined that minimum sample sizes for the SIE-NSM and C-OM groups were 71 and 214 patients, respectively.

Data were presented as mean ± standard deviation (for normally distributed data) or median (upper quartile, lower quartile) for non-normally distributed data. Continuous variables from both SIE-NSM and C-OM groups, such as age, body mass index, tumor size, follow-up duration, surgical duration, incision length, cosmetic outcome score, upper extremity function score, and blood loss, were compared using the independent *t*-test (for normally distributed data) or the Mann-Whitney *U* nonparametric test (for non-normally distributed data). Categorical variables, like local recurrence, tumor stage, hormone receptor status, subcutaneous effusion, and NAC necrosis rate, were expressed in counts and percentages and compared using the chi-square test.

Furthermore, a multivariable binary logistic regression analysis was applied to gauge the risk of local recurrence between SIE-NSM and C-OM, with age and tumor size as covariates. A multivariable linear regression model was used to assess the aesthetic outcomes between the two groups, adjusted for age and body mass index. Similarly, another multivariable linear regression model, adjusted for age, was implemented to investigate the upper extremity function across both groups.

Results

Local recurrence and distant metastasis

Local recurrence was observed in one patient from the SIE-NSM group (1/71, 1.4%) and in two patients from the C-OM group (2/214, 0.9%) (P=0.735). All three patients remained alive after the study's follow-up period after local excision combined with adjuvant chemotherapy and radiation. Furthermore, using age and tumor size as

Table 2 Multivariable binary logistic regression of local recurrence

Variables	Category	β	SE	Wald	OR (95% CI)	P value
Group	C-OM group	Reference				
	SIE-NSM group	0.987	1.306	0.571	2.68 (0.21, 34.71)	0.450
Tumor size	Per 1 cm	1.978	1.044	3.590	7.23 (0.93, 55.99)	0.058
Age	Per 1 year	−0.012	0.064	0.033	0.99 (0.87, 1.12)	0.855

SE, standard error; OR, odds ratio; CI, confidence interval; C-OM, conventional open mastectomy; SIE-NSM, single-port insufflation endoscopic nipple-sparing mastectomy.

Table 3 BREAST-Q† score

Variables	SIE-NSM group (n=71)	C-OM group (n=214)	Univariable, P value	Multivariable, P value‡
Satisfaction with breasts	54.9±6.2	39.5±8.6	<0.001	<0.001
Chest well-being	92.5±8.6	82.2±13.0	<0.001	<0.001
Psychosocial well-being	78.0±11.0	58.2±10.5	<0.001	<0.001
Sexual well-being	63.5±9.9	45.0±8.3	<0.001	<0.001

Data were presented as mean ± SD for continuous data. †, BREAST-Q® version 2.0 © Memorial Sloan Kettering Cancer Center and The University of British Columbia, 2017; ‡, multivariable linear regression adjusted for age and BMI for each aesthetic outcome. SIE-NSM, single-port insufflation nipple-sparing mastectomy; C-OM, conventional open mastectomy; SD, standard deviation; BMI, body mass index.

covariates, a multivariable binary logistic regression was performed to evaluate the risk of local recurrence between the SIE-NSM and C-OM groups. The analysis revealed no significant difference in the local recurrence rates between the two groups [odds ratio (OR), 2.68; 95% confidence interval (CI): 0.21–34.71, P=0.450] (refer to *Table 2*). Importantly, distant metastases were not identified in any patient from either group.

BREAST-Q score

The SIE-NSM group had significantly superior BREAST-Q scores compared to the C-OM group in satisfaction with breasts (54.9±6.2 *vs.* 39.5±8.6, P<0.001), chest well-being (92.5±8.6 *vs.* 82.2±13.0, P<0.001), psychosocial well-being (78.0±11.0 *vs.* 58.2±10.5, P<0.001), and sexual well-being (63.5±9.9 *vs.* 45.0±8.3, P<0.001) (*Table 3*). After adjusting for age and body mass index, the multivariable linear regression model was performed to evaluate the aesthetic outcome between SIE-NSM and C-OM. The scores of various indicators in the SIE-NSM group were markedly better than those in the C-OM group (P<0.001) (*Table 3*).

Subjective value of upper extremity function

The two groups had no statistically significant difference in the upper arm pain score (P=0.162). However, the SIE-NSM group had significantly better scores compared to the C-OM group in chest wall/breast pain (8.68±1.19 *vs.* 7.55±1.12, P<0.001), shoulder range of motion (8.42±1.41 *vs.* 7.30±1.12, P<0.001), and use of arm in daily life (8.44±1.37 *vs.* 7.23±1.21, P<0.001) (*Table 4*). Multivariable linear regression model analysis after adjusting for age was also conducted to explore the upper extremity function of the two groups. The two groups had no statistically significant difference in upper arm pain. However, there was a significant difference between the SIE-NSM group and the C-OM group in chest wall/breast pain, shoulder range of motion, and use of arm in daily life (P<0.001) (*Table 4*).

Length of the incision, operative time, subcutaneous effusion, blood loss, and cost

The length of the incision in the SIE-NSM group was significantly shorter than that in the C-OM group (3.7±0.7 *vs.* 15.0±3.8 cm, P<0.001), and the blood loss was also lower (24.8±20.0 *vs.* 39.7±29.9 mL, P<0.001). There were no cases of subcutaneous effusion in the SIE-NSM group, while the incidence rate of subcutaneous effusion in the C-OM group was 10.7%. This difference between the two groups was statistically significant (P=0.004). The operative time in the SIE-NSM group was markedly longer than in the C-OM

Table 4 Subjective value of upper extremity function

Variables	SIE-NSM group (n=71)	C-OM group (n=214)	Univariable, P value	Multivariable, P value†
Pain upper arm	9.07±1.06	8.87±1.04	0.162	0.161
Chest wall/breast pain	8.68±1.19	7.55±1.12	<0.001	<0.001
Shoulder range of motion	8.42±1.41	7.30±1.12	<0.001	<0.001
Use of arm in daily life	8.44±1.37	7.23±1.21	<0.001	<0.001

Data were presented as mean ± SD for continuous data. Extremity function was based on a scale of 1–10, where a score of 1= poor function and a score of 10= excellent function. The independent samples *t*-test was used to evaluate whether differences between the groups reached statistical significance. †, multivariable linear regression adjusted for age for each upper extremity function item. SIE-NSM, single-port insufflation nipple-sparing mastectomy; C-OM, conventional open mastectomy; SD, standard deviation.

Table 5 Length of the incision, blood loss, subcutaneous effusion, and operative time

Variables	SIE-NSM group (n=71)	C-OM group (n=214)	P value
Length of the incision (cm)	3.7±0.7	15.0±3.8	<0.001
Blood loss (mL)	24.8±20.0	39.7±29.9	<0.001
Subcutaneous effusion	0	23 (10.7)	0.004
Operative time (min)	205.6±40.3	116.5±32.2	<0.001
Mean cost ($)	3,693±927	3,386±774	0.006

Data were presented as mean ± SD for continuous data or n (%) for categorical data. SIE-NSM, single-port insufflation nipple-sparing mastectomy; C-OM, conventional open mastectomy; SD, standard deviation.

group (205.6±40.3 *vs.* 116.5±32.2 min, P<0.001). The mean cost was higher in the SIE-NSM group than in the C-OM group ($3,693±$927 *vs.* $3,386±$774, P=0.006) (*Table 5*).

NAC ischemia and necrosis

In the SIE-NSM cohort, NAC ischemia manifested in three patients (4.2%). The grading of the ischemia was categorized as follows: grade 0 indicated no ischemia; grade 1 represented partial nipple or areolar ischemia; grade 2 indicated partial ischemia of both the nipple and areola; grade 3 corresponded to complete nipple ischemia; grade 4 described complete nipple and partial areolar ischemia; and grade 5 represented total ischemia of both the nipple (15) and areola. Among the three patients in the SIE-NSM group, the occurrences were distributed, with one patient each falling into grades 1, 2, and 3. Preoperative indocyanine green angiography revealed that all three patients had a V1 type NAC blood supply. Following conservative management, all three patients displayed evidence of a scab and localized depigmentation.

Discussion

The continuing advancements in breast cancer screening have enabled the detection of an increasing number of cases at their nascent stages (16). Enhanced diagnostic capabilities have positively influenced the prognosis of breast cancer patients. These improvements have dovetailed with other therapeutic advancements, reducing the need for aggressive treatments and simplifying the path to remission or cure for many (17). While patients understandably prioritize oncologic safety, they concurrently expect—and rightly so—treatment approaches that promote their social, psychological, and sexual well-being. They also seek optimal aesthetic outcomes and a swift return to full functionality. Such evolving patient expectations have led breast cancer surgeons to explore and adopt surgical techniques and care strategies that holistically address both tumor eradication and the patient's overall quality of life.

Although breast-conserving therapy is typically the first choice to treat breast cancer, there are several cases where it is not recommended. For example, patients with diffuse or multiple lesions or patients with a small breast size (which is typical for Asian women) will experience severe breast deformation if a breast-conserving surgery is performed (18). Therefore, the proportion of breast cancer patients receiving breast-conserving therapy is generally lower in China than in Western countries (19,20). However, total mastectomy is also not a desirable choice for most Chinese patients (21). The long, conspicuous scar required by a total mastectomy negatively influences the postoperative aesthetic outcome, and the massive resection of skin can lead to upper extremity dysfunction and further affect the patient's quality of life (22). Due to sparing NAC and avoiding the resection of excessive skin, open NSM improves the appearance of the breast after total mastectomy. Unfortunately, it has a high probability of NAC ischemia and necrosis (23). It would present a prominent scar on the chest wall. Therefore, it does not entirely meet the aesthetic demand of patients.

Endoscopy-assisted NSM is often used to improve postoperative aesthetic outcomes (24). Different techniques to establish the operation space, including the three-port method (25,26), two-independent-incision method (27,28), and the retraction method (29), have been tested. In our study, we introduced the SIE-NSM in which two operations (axillary lymph node staging and mammary gland resection) were completed via a small, inconspicuous single-port incision in the axillary fossa. Additionally, the SIE-NSM established a sufficient operation space by utilizing the insufflation method.

Our study elucidated that the local recurrence rate did not statistically differ between patients undergoing SIE-NSM and those subjected to C-OM, with recurrence rates being 1.4% and 0.9%, respectively (P=0.735). Given the potential tumor spread risks during liposuction, we executed rigorous patient selection. We exclusively opted for early-stage breast cancer patients wherein the tumor was confined to the breast tissue without skin, nipple, or chest wall involvement and for whom preoperative MRI confirmed no glandular protrusion by the tumor.

Surgical precision was paramount: as the superficial gland layer was freed, the scalpel was meticulously maneuvered close to the flap during the procedure. Liposuction efforts aimed to remove adipose tissue between the subcutaneous layer and the gland, a measure designed to eliminate any lingering cancer cells in the subcutaneous tissue. The superficial tumor tissue underwent immediate frozen pathological examination during surgery for added oncologic safety assurance.

However, it was observed that the SIE-NSM cohort had both smaller tumors and a younger age profile when compared to the C-OM group. To account for these discrepancies, we undertook a multivariable binary logistic regression analysis, incorporating both tumor size and age as covariates, to appraise the risk associated with local recurrence. The subsequent findings revealed no significant disparity in the local recurrence rate between the two groups (P=0.450). We acknowledge that these observations necessitate extended follow-up. Validation of these preliminary findings will be sought through an ongoing randomized controlled trial (NCT04461847) comparing SIE-NSM and C-OM, spearheaded by our institution.

Using the BREAST-Q scale, we evaluated the aesthetic outcome and psychosocial well-being after the operation. Satisfaction with breasts, chest well-being, psychosocial well-being, and sexual well-being scores in the SIE-NSM group were significantly better than in the C-OM group. Multivariable linear regression model analysis was performed to adjust for age and body mass index. The results indicated that the SIE-NSM group still had significantly superior scores in the above BREAST-Q outcomes (P<0.001). We hypothesize several explanations for increased satisfaction with breasts and chest well-being. (I) We utilized a short, single-port incision in the SIE-NSM group, which was significantly shorter than the incision in the C-OM group (3.7±0.7 *vs.* 15.0±3.8 cm, P<0.001). (II) No surgical scar on the chest was present because the single-port incision was hidden in the axillary fossa (*Figure 5*). This technique remarkably improved satisfaction with breasts and chest well-being. (III) SIE-NSM spared the NAC and thus improved satisfaction with breasts and chest well-being. (IV) Due to the small breast size, the loss of the mammary gland, yet the sparing of the NAC only affected the symmetry of the breasts slightly. The significant improvement in satisfaction with breasts and chest well-being impacted the psychosocial well-being and sexual well-being in the SIE-NSM group. This suggests that SIE-NSM improves the postoperative aesthetic outcome while improving the psychosocial well-being and quality of life of patients.

Upper extremity function is also an essential factor influencing a patient's quality of life after mastectomy treatment for breast cancer. Conventional mastectomy requires massive chest skin resection, and sometimes the upper extremity movement is limited (30). Whether or not the loss of chest skin and the scar related to the upper extremity function was unclear. This study demonstrated that patients in the SIE-NSM group had less chest wall/

Figure 5 Comparison of the preoperative and postoperative photos. There was no scar visible on the chest wall. The only minor change was the NAC lift (black arrow). NAC, nipple-areola complex.

breast pain, had a better range of motion in the shoulder, and had significantly superior use of their arms in daily life compared to the C-OM group (P<0.001). Because the patients in the SIE-NSM group were generally younger, a multivariable linear regression model analysis after adjusting for age was conducted. The results were similar. This indicated that SIE-NSM reduced the traction of the chest wall scar to the upper extremity by preserving the integrity of the skin on the chest. Therefore, this improved upper extremity function and quality of life.

NAC ischemia and necrosis are common and serious complications after open NSM, and the highest incidence rate of ischemia is 64.1% (15). NSM with an incision on the breast surface can damage the skin and subcutaneous vasculature of the breast, while the areolar incision can directly damage the NAC blood supply and lead to a high incidence rate of NAC ischemia and necrosis (28). A recent study has shown that endoscopic NSM with an axillary incision can significantly decrease the incidence rate of NAC ischemia and necrosis (31). Only three SIE-NSM patients (4.2%) in this study developed grade 1–3 NAC ischemia. No grade 4 or 5 (severe) NAC ischemia or necrosis was observed. We hypothesize that: (I) the covert single-port incision in the axillary fossa avoided a breast surface or areolar incision; (II) the deep nipple mammary duct excised by laparoscopic scissors, which reduced the deep thermal damage caused by a harmonic scalpel or electrocautery; and (III) the blood supply of the NAC and skin flap was assessed by indocyanine green angiography before the operation (32,33).

The blood supply to the NAC can be classified by where the perfusion originates (34,35). Type V1 originates predominantly from the underlying breast tissue (*Figure 6A*), type V2 originates from the surrounding skin (*Figure 6B*), and type V3 is a combination of V1 and V2 (*Figure 6C*). For type V1, when the mammary gland resection occurs, the vertical blood supply will be completely damaged, and ischemia and necrosis will happen easily. In our study, 24 patients had type V1 NAC blood supply, and three patients with NAC ischemia were in this group. Compression dressings should be avoided as much as possible after the operation to minimize the impact on the NAC blood supply. We also used nitroglycerin ointment (a local vasodilator) in the patients with type V1 NAC blood supply because Gdalevitch *et al.* (36) found that the use of nitroglycerin ointment could improve the blood supply to the skin flap and reduce necrosis in patients undergoing NSM and immediate reconstruction. For type V2 and type V3, the mammary gland resection has little impact on the NAC blood supply, and compression dressing can be generally implemented after the operation.

Subcutaneous effusion is a common complication after total mastectomy and can significantly influence the rehabilitation process of patients. We observed that the incidence rate of subcutaneous effusion was 10.7% in the C-OM group and 0% in the SIE-NSM group (P=0.004). This observation can be explained by the following possible causes: (I) the heat from the electrotome used to dissect the skin flap in C-OM results in fat liquidation, which increased the risk of subcutaneous effusion. In the SIE-NSM group, the dissection of the skin flap was performed with laparoscopic scissors, which reduced the production

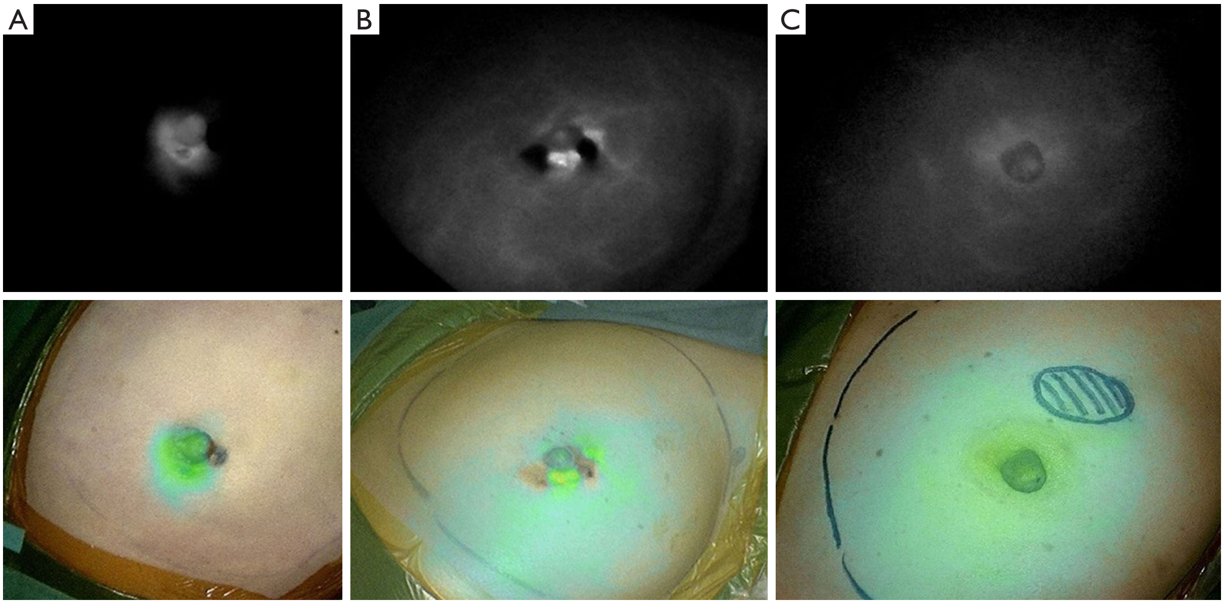

Figure 6 The blood supply to the NAC can be visualized by ICG angiography. (A) Type V1 originates predominantly from the underlying breast tissue; (B) type V2 originates from the surrounding skin; (C) and type V3 is a combination of V1 and V2. NAC, nipple-areola complex; ICG, indocyanine green.

of subcutaneous effusion; (II) liposuction during SIE-NSM significantly decreased the fat content in the breast and reduced the occurrence of fat liquidation; and (III) after liposuction, the endoscopic amplification clearly displayed the membrane anatomy and ligaments around the mammary gland (12), which avoided damage of the membrane anatomy and reduced subcutaneous effusion.

In our comparison of the SIE-NSM and C-OM procedures, the SIE-NSM approach demonstrated a substantial reduction in blood loss (P<0.001). This can be attributed to the clear visualization of the mammary gland's surrounding membrane anatomy and the precise dissection between these structures. Furthermore, the preoperative use of a tumescent solution containing epinephrine constricts blood vessels, further reducing blood loss. Regarding operative duration, the SIE-NSM procedure took notably longer than C-OM (P<0.001). This longer duration is due to the intricate technique required for endoscopic surgeries and the additional time for liposuction, which creates an operational space and exposes the membrane anatomy. While the prolonged operative time impacts anesthesia costs, and the requirement for specialized laparoscopic instruments increases the total cost, the advantages of SIE-NSM, such as decreased blood loss and potential improvements in postoperative quality of life, make it a compelling option for consideration.

Conclusions

Our retrospective cohort study revealed that SIE-NSM offers comparable safety to C-OM in early breast cancer patients, as evidenced by the analogous rates of local recurrence and distant metastasis. Beyond safety, SIE-NSM was associated with enhanced aesthetic results and superior scores in sexual well-being, psychosocial health, and upper extremity function. Additional advantages included reduced subcutaneous effusion rate and decreased intraoperative blood loss. An ongoing randomized controlled clinical trial (NCT04461847) aims to further validate the oncologic safety and aesthetic benefits of SIE-NSM for those breast cancer patients who either cannot or choose not to undergo breast reconstruction. Our findings strongly suggest that SIE-NSM can significantly bolster postoperative aesthetic outcomes and improve psychosocial health for patients opting out of or unable to undergo breast reconstruction.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted per the Declaration of Helsinki (revised in 2013). This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (No. 2019-P2-033-02). Informed consent was waived due to the retrospective nature of this study.

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